Description

Shielded duplexer with lower overall height

A duplexer is a crossover network that separated the reception and transmission signals of a certain frequency range of a data transmission system, whereby the data is transferred in both directions through a common antenna. As a rule, the duplexer shows a band pass filter in any signal path, for instance a filter that operates with acoustic waves or a filter, which consists of multiple electrically and mechanically connected dielectric resonators which are for instance manufactured in microwave ceramic material. Thereby, the duplexer guarantees that the paths do not mutually influence each other and for example a transmission signal is not inserted in the reception path.

A known microwave ceramic filter consists at least of a resonator, which is manufactured in a dielectric ceramic basic element. What's more, the basic element shows a central drill hole, the internal walls of which are metal coated. The external walls of the ceramic basic element are also metal coated with the exception of an end face and are connected with the metal coated drill hole on the short-circuit side, which is positioned on the opposite side of the non-metal coated end face. Through galvanic isolation from the outside metal coating, electrical terminal faces can be found on the bottom side or on a lateral face. These terminal faces are used for the capacitive connection with the metal coated drill hole, which constitutes the actual resonator.

Microwave ceramic filters have the advantage that they are of comparatively simple design and can be manufactured in a cost-efficient manner.

Additionally, the filters feature a low insertion loss.

Patent US 5 686 873 features a monolithic duplexer. One single ceramic body is provided in this case, in which a transmission channel and a reception channel are configured with multiple coupled resonators. The advantage of such a monolithic duplexer lies in its production: only one ceramic body needs to be pressed into a unit which simplifies the production considerably compared to the manufacturing of two ceramic bodies.

Patent US 5 959 511 B1 features a monolithic duplexer, which shows a metallic shielding plate for the electromagnetic shielding and improvement of suppression loss between Rx filters (input filter or receiving filter) and Tx filters (send or output filter), which is placed at a short distance from the end face of the duplexer with the resonator drill holes leading to that and which stretches across at least part of the top side of the duplexer over the entire width. This raises the overall height of the duplexer depending on the strength of the plate by 0.2 mm which is necessary to provide sufficient stability to the shielding plate. When the target overall height is approx. 2 mm, this is still only 10% of additional height.

Different characteristics of microwave ceramic filters, such as the performance in particular, depend on the height of the filter measured diagonally from the resonators. A further minimization of the overall height, as desired by the user of the filter, will be limited by nature with regard to the quality losses in connection with that, since it results in a considerable loss of performance and particularly in an increase of the insertion loss in both channels.

For that reason, the purpose of this invention is to specify a duplexer with shielding which features a lower overall height compared to known duplexers with shielding and at least constant electrical characteristics.

This task is solved by a duplex according to claim 1. The beneficial embodiments of the invention can be gathered from additional claims.

A duplexer is defined in which an RX-filter and a TX filter are designed in at least one ceramic base. Each of the filters features metal-coated drill holes on the inside, which reach from one end face of the ceramic base to the end face of the floor space on the opposite side. Every base features an external metal coating which predominantly covers the surfaces of the base with the exception of the end face. According to the invention, a metallic shielding structure is provided that features an upper shielding clamp adjacent to the top side of the base at a limited distance from the end face and parallel to this frontal head plate, and at least one lower shielding clamp reaching under the base. The parts of the upper and lower shielding clamps, which come in contact with the base, run in these upper and lower depressions in the surface of the base.

The ceramic base of a duplexer with shielding clamps countersunk in this manner has a higher volume when the dimensions are constant than the base of a known duplexer with conventional shielding structures. This means that the quality of the duplexer according to the invention has improved compared to the known duplexer when the outer dimensions are constant. Alternatively, a duplexer can be manufactured just as before when the quality is constant with outer external dimensions.

In addition, the compact construction of the duplexer according to the invention is advantageous. Preferably, the surfaces of the ceramic base are flush with the surfaces of the corresponding parts of the shielding structures and/or the shielding clamps that are pointing

outward. The shielding clamps sunk into the surface of the base also result in the fact that a more firm hold of the shielding structure on the base is obtained. A duplexer according to the invention can already be used without additional closure by adhesion or bonding of the shielding structure. The good mechanic hold of the shielding structure on the base also guarantees a good secured condition in case of a further fastening by means of soldering or bonding. Additionally, the cavities guarantee a precisely tailored fit of the shielding structure on the base, which corresponds exactly with a position that is specified and desired by the cavities, in which the shielding clamp and, consequently, the shielding structure can lock into place.

A duplexer according to the invention can consist of a single monolithic, ceramic base in which RX-filters and TX-filters have been provided. Thereby, the upper shielding clamp features a longitudinal section running parallel to the longitudinal axis of the drill holes, which is narrow in design in relation to the width of the base. In other words, said longitudinal section only covers part of the surface, whereby the base, on both sides of the longitudinal section, shows a larger height than in the area of the longitudinal section and/or the corresponding cavity. The width of the upper shielding clamp and, in particular, the width of the narrow longitudinal section is selected in such a manner that a sufficient shielding function is obtained. Simultaneously, the surface portion of the cavity, which corresponds to the surface of the upper shielding clamp on the top side of the base, is minimized, as a result of which the volume of the base can be set to a maximum value with the outer dimensions given.

However, it is also possible to provide bases separated from one another for the RX-filter and the TX-filter, which are preferably arranged at a distance from one another in the duplexer. In this case, the upper shielding clamp features a longitudinal section running parallel to the longitudinal axis of the drill holes, which is narrow in design in relation to the width of the base,

centrally located above the joint between both bases and which overlaps part of the top side of both bases. For this reason, it is guaranteed that the upper shielding clamp embraces both bases and fixes these in relation to the shielding structure and in relation to one another. In this case, a widened shielding clamp or two lower shielding clamps at a distance from one another are provided. It is of course also possible that two upper shielding clamps are provided which each securing one of the two bases. With regard to the shielding function, it is beneficial to centrally locate the upper shielding clamp in the area between the RX-filter and TX-filter.

The lower shielding clamps have a purely mechanical function for securing the shielding structure to the base and/or for securing the base or the bases to the shielding structure. It suffices only to provide a lower shielding clamp, and a lower shielding clamp which reaches under the base with only one clamp. However, the shielding structure preferably features two lower shielding clamps and two clamp ends that reach under the one monolithic base or under both bases at a distance from one another. The provision of two lower shielding clamps has the advantage that a three-point securing for one or multiple ceramic bases emerges together with the upper shielding clamp. In addition, a central area at the base between both lower shielding structures remains freely accessible so that the commonly provided coupling structure, which forms an electric connection surface to be connected with the outer circuit area, remains freely accessible.

The lower shielding clamps are preferably as short as possible in design, so that a sufficient mechanical hold is guaranteed through the reaching under the base(s).

An advantageous shielding structure features a front or head plate, which is extended on both lateral, outer ends and runs into lateral shielding clamps, which are folded towards the back in the direction of the ceramic base and which laterally embrace the base(s). The lateral shielding

clamps also run in lateral cavities within the surface of the base(s), whereby the height of the lateral shielding clamp is lower than the height of the ceramic base(s).

This arrangement has the advantage that the ceramic base(s) are even better secured in relation to the shielding structure and in relation to one another.

Both lower shielding clamps advantageously build a π-shaped structure together with the head plate, while the upper shielding clamp forms a T-shaped structure together with the head plate. The T-shaped part of the shielding structure can be designed in such a manner, that exclusively the foot of the T bears on the top side of the base, where it features the longitudinal section. However, it is also possible that part of the crossbeam bears on the top side of the base. The crossbeam curves downward at its end and forms there the folded part of the head plate.

It is beneficial when the upper shielding clamp does not stretch across the entire length of the base(s) and, for that reason, does not reach its floor surface.

The shielding structure can be connected with the base(s) alone by means of mechanical locking and seizing mechanisms and also by means of bonding or soldering. The connection preferably takes place in the area of the external metal coating which is subsequently connected to ground. In this way, the shielding structure is simultaneously grounded through the grounding connection of the external metal coating and a better shielding effect can unfold as a result thereof. However, it is also possible to connect the shielding structure with an outer ground connection so that a separate connection of the external metal coating can unfold at an outer ground connection.

As mentioned earlier, the shielding function of the shielding structure is predominantly achieved through the head plate and the upper shielding clamp, which, on the one hand, protects the drill holes leading to the head surface of the base(s) against external influences and, on the

other hand, provides for a better unilateral conductivity between the RX-filter and TX-filter through the upper shielding clamp. However, it is advantageous when the height of the head plate is lower than the height of the ceramic base. In this way, the drill holes in the head surface remain accessible so that it is possible to trim an individual filter of the duplexer or of the overall duplexer after raising the shielding structure. Trimming can be prevented by removing material in the area of the drill holes at the head surface.

An advantageous execution of a head plate and lateral shielding clamps consists of a narrow metallic strip of equal width, the ends of which, which are bent backwards in the direction of the ceramic base, form the lateral shielding clamps.

Hereinafter, the invention is further clarified on the basis of executions and the accompanying figures. In order to get a better understanding, the figures are not to scale and only schematically presented whereby the finest details have not been taken into account.

Figure 1 shows a duplexer according to the invention at an angle from the top,

Figure 2 shows a duplexer according to the invention from the side,

Figure 3 shows a duplexer according to the invention from the top,

Figure 4 shows an additional variable of a duplexer according to the invention at an angle from the front side and the top.

Figure 1 shows an advantageous design of a duplexer according to the invention. Essentially, the duplexer comprises an initial filter F1 and a second filter F2, which are designed as RX-filter and TX-filter and could be featured in one single monolithic base or in two ceramic bases separated one from the other. Dotted line TL symbolizes the virtual separation in a monolithic base and/or the real separation between two separated bases.

Shielding structure ST preferably consists of one unit and includes accordingly a punched and bent sheet metal which is slit on the base(s) GK. The displayed shielding structure ST comprises a head plate SP, an upper shielding clamp OB, two lower shielding clamps UB, as well as two lateral shielding clamps SB. The head plate SP and the lateral shielding clamp SB in the presented advantageous execution show a unified height h_s which is lower than the height h_g of the base GK.

Each of both filters shows metal-coated resonator drill holes RB on the inside, which stretch across the entire length of the base. At least two resonator drill holes are provided per filter. However, each filter advantageously possesses, as shown, three (as shown) or more resonator drill holes whereby a central drill hole constitutes a so-called coupling drill hole with which poles and notches are realized with which, when in immediate proximity of the pass-band, the side of the pass-band can become steeper or with the help of which, alternatively, a desired frequency can be filtered.

The shielding structure is preferably made out of a non-magnetic sheet metal, the strength of which is selected according to criteria of stability. For instance, sufficient stability features a steel panel of approx. 0.1 mm in density so that this density is preferably between 0.15 and 0.20 mm. However, it is also possible to produce shielding structure ST of other metals or alloys, for example from German silver or copper alloys. Good electrical conductivity is decisive to achieve the shielding effect. It is advantageous for better processing when the shielding structure and the material of the shielding structure, respectively, demonstrate good soldering features. The latter can be procured through suitable material selection and also through a corresponding thin coating on a material that does not permit soldering.

A certain minimum distance of the head plate SP from the head surface SF is required for a good functioning of the duplexer. This distance is for instance equal to 0.5 mm.

The upper shielding clamp OB, the lateral shielding clamp SB and lower shielding clamp UB are located on the ceramic base GK in corresponding depressions and cavities, respectively, so that the surface of the shielding clamp locks flush with the other surface of the exposed base.

Figure 2 shows a duplexer according to the invention as seen from the side. The lateral shielding clamp SB is shorter in the presented embodiment and does not reach across the entire length L_G of the base GK. It is also easy to notice that the lower shielding clamp UB is very short in shape and reaches directly under the base GK. The upper shielding clamp OB reaches across the entire length L_G of the base GK in the embodiment. The interrupted line demonstrates that the upper and lower shielding clamp are located behind the drawing level, run in cavities and, consequently, do not overlap the surface of the base GK and the underside of the base, respectively. Hence, the overall height of the duplexer in the shown embodiment corresponds to the height h_G of the base. A suitable height is for instance equal to 2 mm.

The distance of the head plate SP from the head surface SF can be easily recognized in the figure. Additionally, the figure demonstrates in which arrangement the duplexer is located and mounted on a base plate BP. The underside shows the base plate on which the electrical connections to the corresponding connector surfaces on the underside of the base(s) are made for the external metal-coating or for the shielding structure ST.

The view also makes it clear that the co-planarity of the duplexer is essentially determined by the attainable co-planarity of the ceramic base GK, as well as by the attainable co-planarity of the shielding structure ST in the area of the lower shielding clamp UB. Today's

methods attain for instance a maximum deviation from the level of 0.02 mm for the ceramic body, while maintainable tolerances in the case of the shielding structure are close to only 0.01 mm.

Due to these small deviations, the overall height of the duplexer is further reduced and the soldering on a base plate BP, for instance a conductor board or a printed circuit, is facilitated.

Figure 3 shows a duplexer according to the invention as seen from above. It consists of two bases, which form an initial filter F1 and a second filter F2. Both filters, the RX-filter and TX-filter are located at a small distance from one another of about 0.1 to 1.0 mm, for example at a distance of 0.5 from one another. This view easily shows that the shielding structure ST, with the exception of the head surface, is flush on all sides with the ceramic base and both ceramic bases, respectively, and does not protrude over this one. The cavities, in which run the safety clamps on the base GK, are so deep that these directly conform to the material strength of the metal used for the shielding structure ST.

Figure 4 shows an additional embodiment of the invention with a differently designed shielding structure. This embodiment is also suitable for a single monolithic base GK or presented in relation to the figure for a duplexer in which the RX-filter and TX-filter each consist of a base GB. The shielding structure consists of an upper shielding clamp OB, a head plate SP and two lower shielding clamps UB. The upper shielding clamp OB consists of a longitudinal section LA, which is located parallel to the longitudinal expansion of the resonator drill holes RB and covers the separate joint between both bases GK and/or between both filters F1 and F2. The upper shielding clamp passes into a cross section QA in the direction of the head surface SF of the base. This cross-section features a larger width than the longitudinal section LA and forms a T-shaped structure together with the latter. The cross-section of the upper shielding clamp is

placed partially on the bases GK, protrudes with the rest and is bent at the end where it forms the head plate SP. The latter, in itself, runs downward in the shape of a fork into two lower shielding clamps UB, which have been re-curved on the underside of the base and reach under these. All surfaces of the shielding structure ST, which bears on the bases GK, run in corresponding depressions within the base and flush with the surface of the base.

The head plate SP of the shielding structure permits good access to all of the resonator drill holes RB of both filters F1 and F2 and permits in this way, after connecting the filter with the shielding structure, subsequent tuning, trimming or compensation. Nevertheless, this shielding structure, reduced in size, satisfied the desired purpose of optimal suppression loss in RX and TX-band, respectively (in the direction of the respective counter-band), as well as good insulation of the RX-band against the TX-band and vice versa. Based on the relatively wide cross-section QA of the upper shielding clamp, a particularly good securing of two bases is achieved with this embodiment. Hence, this embodiment is particularly suitable for a modularly constructed duplexer made of two independent individual filters F1 and F2.

Although the invention was only described based on few embodiments, it is not restricted to this one. Further designs of the invention are possible with respect to the precise geometrical design of the shielding structure.

Also with respect to the other precise design of the filters and of the ceramic bases, of the resonator drill holes and of those not displayed, further variations are possible on the capacitive connector surfaces located on the underside of the base. However, all embodiments have the low overall height of the duplexer in common, which distinguishes itself from known duplexers with the shielding feature. Variations are also possible with respect to all materials and measures exemplified in the embodiments.